Microseism Monitoring System for Coal and Gas Outburst

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Abstract
The outburst forecast of coal and gas is a complex system engineering. On the basis of the analysis of microseism monitoring principle, a simplex positioning algorithm for microseism monitoring is designed; a mine microseism monitoring system is established to canalize mine microseism. Mechanism of the error producing and noise reduction measures is studied. We can analyze the data of the microseism monitoring to find coal or rock vibration caused by mining activities. Microseism monitoring system can capture real-time positioning information. It also can timely, accurately monitor and position these microseism events and the mining microseism event, which provide the pressure monitoring, the prediction of gas outstanding and the next step gas coal bed mining monitoring with reference experience.
Keywords: *Coal and Gas Outburst, Microseism Monitoring, Simplex Type, Mining Dynamic Disaster Prediction*

1. Introduction

Coal and gas outburst is a kind of complex dynamic phenomenon, it possess sudden and extremely strong devastating feature [1]. Exhaled gas pulverized accompanied by a powerful impact to the destruction of the roadway facilities, resulting in airflow reversal, the destruction of mine ventilation system to bring great harm to the mine. Coal and gas outburst has become the number one enemy of the coal mine production safety [2].

As a kind of natural disasters, coal and gas outburst with a certain regularity, and sudden precursor, in theory, has the predictability and preventability [3]. Coal and gas outburst source region of the most important feature is the high fissures, high pore pressures and high gas content. Although there are a variety of geophysical methods can monitor the three features of the source area of the gas. But in all the earth's physical indexes, seismic wave propagation speed is the only index that can effectively reflect the characteristics of the three changes at the same time [4].

Microseism monitoring technology is a high-tech development in recent years, by use of acoustic emission, seismology and geophysics theory and computer powerful features to achieve the precise location of microseism events and determining the level size. Using seismic monitoring system in place of the seismic activities in the place where ore emplaced with acoustic sensors, to detect the collapse of launched out seismic wave, and to determine the position of the seismic wave, giving the seismicity intensity and frequency. The distribution of the broken position measured by the seismic monitoring applies to judge potential activity rules of coal and gas outburst. Through the recognition of coal and gas outburst precursors' activity rules, the prediction of the gas outburst is achieved. Establishing coal and gas outburst microseism monitoring systems can effectively prevent the occurrence of gas outburst disasters, serving as a model for the application of microseism monitoring technology in the gas outburst monitoring[5]-[6].

2. The Principle of Microseism Monitoring

Rock under stress in the outside world, the local elastic-plastic concentration phenomenon produces in its internal. When the energy accumulates to a critical value, it causes the generation and expansion of the micro-cracks. The production of micro-cracks and expansion is accompanied by elastic wave or stress wave that release and spread quickly in the surrounding rock mass, namely, acoustic emission, relative to the larger size rock, also known as the microseism in geology. (Microseism, MS) [7].

Coal as a kind of particular material that have an amount of pores and cracks, has the features of low intensity, poor heterogeneity, including methane gas and discontinuous . In the whole process of destruction by the load, coal-fired signals will be extremely rich while the frequency of the acoustic emission signals should not be too high and the signal energy is not too large. The acoustic emission events should be intermittent pulse signal. Near the destruction, the signal of the acoustic emission will be more concentrated and greater [7]- [8].

The microseism basic principle: the coal rocks damaged under stress, and produce microseism and acoustic wave. The layout of multi-detector in the roof and floor of the mining area and real-time microseism data acquisition, after data processed, utilizing vibration positioning principle to determine the location of the rupture, and displayed on the three-dimensional space[9].

Microseism positioning monitoring compared to traditional technology, it has features of long-rang, dynamic, three-dimensional, real-time monitoring, which can also in accordance with the situation further analysis of scale and nature of the rupture. It provides a new mean for the study of overburden rock space fracture morphology, mining stress field distribution and coal power disaster monitoring and forecasting. Microseism monitoring is an integral part of the mining process, with a high positioning accuracy, has become the main technique for monitoring the dynamic disasters which is induced mining. The distribution location of micro-rupture by microseism monitoring to determine the potential of activity patterns coal and gas outburst, through the identification precursor activity patterns of coal and gas outburst to reach gas outburst forecast[9] -[10].

3. Microseism Monitoring Location Algorithm Design

The simplex algorithm is a nonlinear optimization iterative method, is among the most optimized unconstrained class method of direct search method, first proposed by Spindly, Hext and Himsworth, and then improved by Nelder and Mead. The First Gendzwill and PlUgger use simplex method to the positioning of the seismic events [11].

Simplex is a kind of multi-polytope. Solving n-dimensional equations requires the establishment of the simplex with n+1vertices not in the same hyperplane. For example, the triangle is a simplex for solving two-dimensional equation; the tetrahedron is a simplex for solving three-dimensional equation.

Acoustic emission event location is mainly through the different position sensors to pick up P wave time to the inversion acoustic emission event source position. That is, first identify P wave arrival time, using time difference through the simplex algorithm is proposed to realize the orientation of acoustic emission events. The mathematical calculation principle is: the first f sensor to concerned, acoustic emission sources to the distance sensor for next type the calculated results;

In the formula:. --The coordinates of the i-AE sensor; --The measured wave velocity of the i th probe at; --arrival time;.. --Source coordinates; --Rupture time.

Assume that No. 1 sensor is the location of the reference sensor, for the time difference and the position difference which come from the specific location of acoustic emission source to the l and i sensor. For the difference of time and position, the application of the simplex algorithm inversion of acoustic emission source position to achieve the acoustic emission orientation of the event.

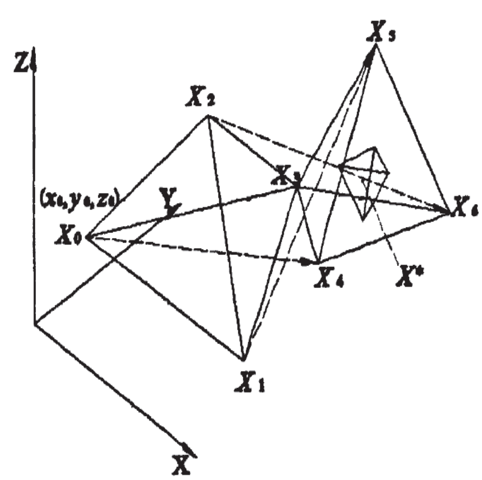

Figure 1 Three-dimensional simplex schematic

4. The design of Microseism Monitoring System

The application of microseism technology for coal and rock mass stability forecast. We concerned about whether coal and rock mass produce such activities, and even may lead to the gas outburst and other destructive phenomena of location, time and degree of instability. Acoustic emission and micro-source precise positioning is one of the vital technologies about the methods and the first step for the mine seismic activity monitoring research. In addition, it is an important indicator to test and evaluate a microseism monitoring system [12]-[13].

The principle of the monitoring positioning is: a sensor array made up of a certain number of sensors in a certain degree of network will be distributed around the seismic source, when acoustic emission and microseism occur in the body. Then microseism sensor will pick up the signal and this physical quantity is converted to the amount of voltage or the amount of charge. Through multi-point synchronous data acquisition determinate the time that each sensor receives the signal, together with the sensor coordinates and the wave velocity measured into the equations to solve. You can determine the spatial and temporal parameters of the micro-focal positioning purposes.

The system is composed of three parts: the ground-based data processing system, the coal mine data acquisition system and the sensors. The signal acquired by 30 sensors, which is outputted by the amplifier built-in sensors. It sent to three microseism loggers which placed in the level of -662m and -710m Paladin through the signal cable, by digital-analog conversion, then the ground data transmitted by optical fiber for processing systems analysis.

It achieves real-time monitoring, remote data acquisition and remote monitoring through the connection with the mine network centre . And information through a wireless transmission system connected the computational analysis system.

5. Microseism Signal Processing

Microseism monitoring recording has obvious characteristics of the waveform, big amplitude, low frequency, short duration, the sensor receives waves not at the same time. Microseism monitoring source waveform is shown in Figure 3.

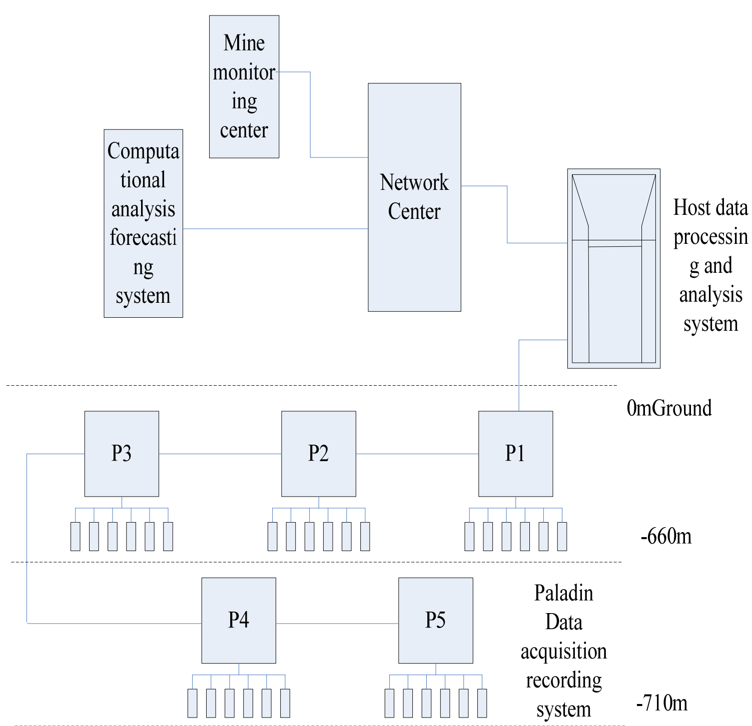

Figure 2 The sketch map of the microseism monitoring system composition

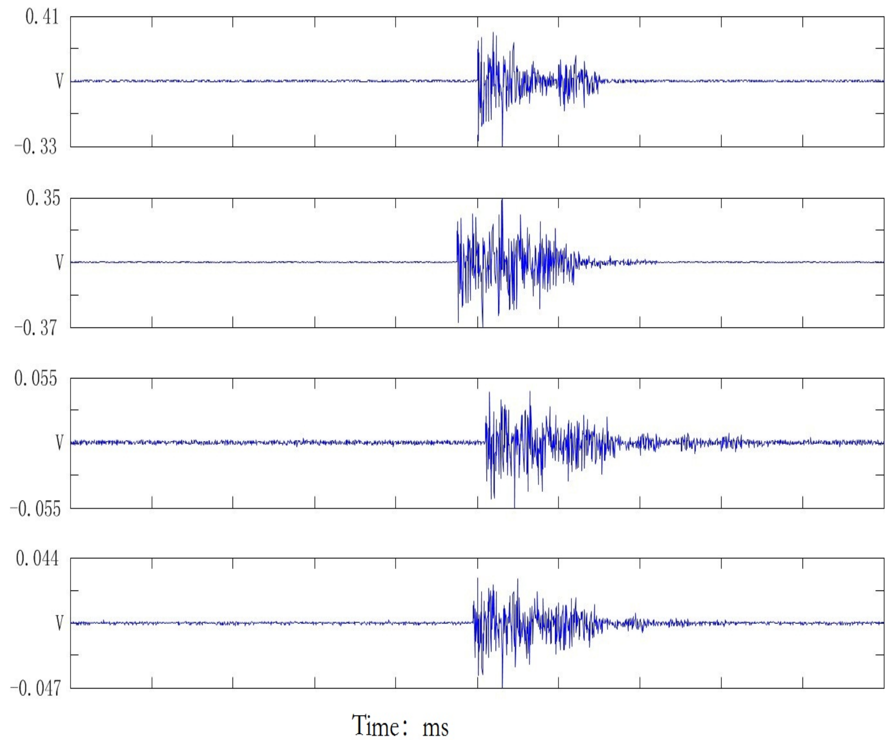

Figure 3 the detected waveform of the microseism source

Within the scope of the system and testing, for various reasons, such as face forward mechanical activity, the operation of the fan and coal transport the signals generated by microseism monitoring system receives. Underground noise source can be categorized as follows: electrical noise; machine operations noise; human activity noise; random noise. The noise part of the electrical noise is white noise, that is, the various frequency components have little change in amplitude, mainly generated by the electronic components, basic fixed part of the noise frequency is generated by the device to run induction. Machinery operating noise is focused on producing a large number of signals, mechanical operations, and has a clear periodicity, which is inherent in the mechanical operation of the frequency. Human activities noise is the most difficulty to filter out. In that it generates forms diversification and shows the weak general regularity, wide frequency range, changes great amplitude, the characteristics are generally not very obvious. Random noise is characterized by both large and small amplitude, frequency of high-frequency, low -frequency components, but the signal appears more concentrated.

Band of each event, some interference can be distinguished easily from micro-shock wave. Therefore, although there is a variety of interfering signals underground, and some dry turbulence signal is very strong, in fact it is very easy to separate effective signal form dry turbulence signal and will not interfere with the normal earthquake detection, for data interpretation and positioning won't bring a lot of influence.

6. Conclusion

This system is mainly to monitor the security risks of the coal mine and prevent the occurrence of gas outburst in mining or tunneling process. On this account that the system has been just set up and the mining coal seam has just been for the low-gas coal, microseism events are not so many, but by analyzing the microseism monitoring data we can find the Coal-rock vibration is caused by coal mining activities. Microseism monitoring system can capture real-time positioning messages. Microseism events for the accurate monitoring, position and with the process of mining of microseism positioning are expressed by timeliness and accuracy. They provide a reference for the ground pressure monitoring of the activities as well as the prominent disasters forecast and the monitoring experiences of the next step in high gas coal seam.

This paper is supported by the Youth Foundation of Anhui University of science & technology of China under Grant No.2012QNZ06 and also supported by the Doctor Foundation of Anhui University of science & technology of China under Grant No.11223.Natural Science Foundation of Anhui Provincel of China under Grant No.KJ2012B062.

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